Space Technology Research Grants

Perception-Aware Spacecraft Motion Planning

Completed Technology Project (2016 - 2020)

Project Introduction

Motion planning entails autonomously planning and executing trajectories in dynamic and cluttered environments while obeying differential and other constraints such collision avoidance. Implementing motion planning algorithms to the realm of spacecraft guidance and control includes additional challenges such as operating in uncertain environments and necessitating fault-tolerant operation without human intervention. As such, fast re-planning and anytime computation poses its own set of challenges before accounting for the need to implement such algorithms on spacecraft embedded systems. This project will focus on the development of real-time, efficient, and dependable algorithms for autonomous maneuvering, with a focus on dynamic and cluttered environments. Leveraging advances from the fields of robotic motion planning and control, this work seeks to devise a technology for real-time, safe planning of trajectories in a range of missions such as proximity operations, attitude motion planning under complex constraints, and satellite reservicing missions. The foundation of this work will be steeped in sampling-based motion planning, an approach that scales well to high-dimensional systems and has a rich history of work at the Autonomous Systems Lab (ASL). The open research avenues on this topic include: - Leveraging embedded graphics processing units (GPUs) and embarrassingly parallel algorithms for GPUs to enable new modes of real-time planning for spacecraft systems. - Robust control of high-dimensional systems (i.e. spacecraft equipped with a robotic arm) in order to guarantee performance and provide safety certificate in the presence of uncertainty. - Theoretical analysis of bottlenecks in the planning process i.e. the calculation of nearest-neighbors for sampling-based planners. - Incorporating work from the field of machine learning and AI to increase autonomous capabilities of spacecraft while guaranteeing safe operation in new and unforeseen environments. Although these listed topics cover a broad swath of work, they will be developed with a specific eye on the aforementioned mission-enabling spacecraft applications.

Anticipated Benefits

This project could benefit dozens of CubeSat missions in academia and industry that use reaction wheels by implementing an aerodynamic torque desaturation methodology that would allow for more volume, mass, and power to be dedicated for an additional RW, expanded science payload, or miniature electric propulsion thruster to enable a greater capability for missions.

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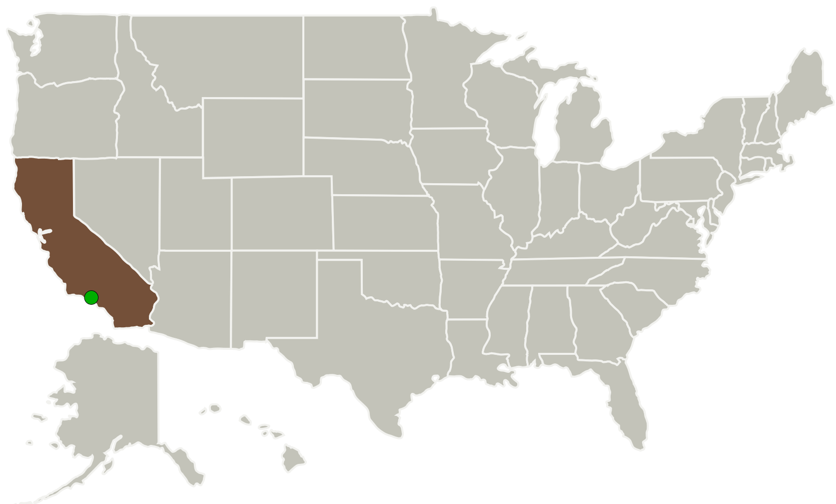
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Stanford University(Stanford)	Lead Organization	Academia	Stanford, California
Jet Propulsion Laboratory(JPL)	Supporting Organization	NASA Center	Pasadena, California

Primary U.S. Work Locations
California

Project Website:

https://www.nasa.gov/strg#.VQb6T0jJzyE

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Stanford University (Stanford)

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

Marco Pavone

Co-Investigator:

Abhishek S Cauligi

Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **3**

1 2 3 4 5 6 7 8 9

Applied Research | Development | Demo & Test

Technology Areas

Primary:

- TX10 Autonomous Systems
  └─ TX10.2 Reasoning and Acting
    └─ TX10.2.3 Motion Planning

Target Destination

Earth